INCOSE Los Angeles Chapter

Advancing the Practice of Systems Engineering at JPL

June 12, 2007

JPL Panel (Jones, Derro, Burns, Blom, Jansma)
Systems Engineering Advancement (SEA) Project

California Institute of Technology

INCOSE Los Angeles Chapter

Panel Presenters

JPL

- Ross Jones – SEA Project Manager

- Mary Ellen Derro – SEA People Element, HR Organizational Development Specialist and SE OJT Behavioral Coach

- M. J. "Peggy" Burns – SEA People Element, HR Professional Development, Technical Instructional Designer

- Kris Blom – SEA Processes, Products, Tools and Technology Element

- P. A. "Trisha" Jansma – SEA Deployment Element

Topics To Be Covered

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- SEA Background
  - Mission of the SEA Project
  - Scope of Systems Engineering at JPL
  - Systems Engineering Product Domains
- Three Key Components of Change
  - People Component
  - Process: Systems Engineering Practices
  - Technology: Model-Based Engineering
- Three Support Components of Change
  - CRM: Customer Relationship Management
  - OCM: Organizational Change Management
  - Deployment
- Summary
- Backup Slides
  - Details of Deployment Process
  - Details of SE OJT Program

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Mission of the SEA Project

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- The mission of the Systems Engineering Advancement (SEA) Project is three-fold:
  - To measurably improve the practice of systems engineering at JPL,
  - To contribute to increasing efficiency and decreasing the risk associated with the development and operation of JPL's flight projects,
  - To ensure there is a pipeline of qualified systems engineers with the critical skills needed now and for future missions.
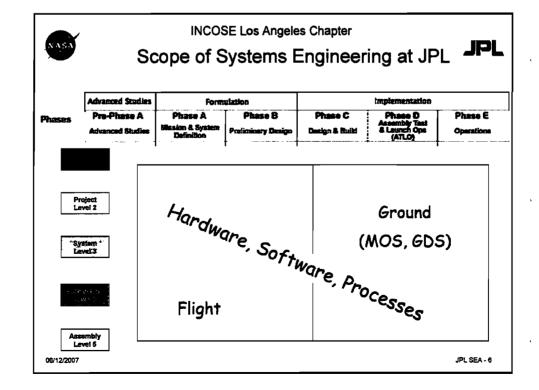
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Scope of Systems Engineering at JPL

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- **Technical Scope**: The systems engineering process is defined to include 10 technical functions:
  1. Develop System Architecture
  2. Develop & Maintain Requirements
  3. Analyze & Characterize the Design
  4. Manage Technical Resources & Performance
  5. Develop & Maintain Interfaces
  6. Verify & Validate
  7. Conduct Reviews
  8. Manage Risk
  9. Manage & Control the Requirements & Design
  10. Manage the SE task

> • *SE is practiced across the full life-cycle, technical scope and at all levels in a flight project.*
> • *It also includes SE behaviors.*

- **Systems Engineering Levels**
  - Level 1 – Program
  - Level 2 – Project
  - Level 3 – System (Flight, Mission Ops, and Launch)
  - Level 4 – Subsystem (Avionics, Electrical Power, Instrument, Mechanical, Propulsion, Telecommunications, Thermal, Software, etc.)
  - Level 5 – Assembly or Element

- **Full System Life-Cycle**
  - Pre-Phase A – Advanced Studies
  - Phase A – Mission and System Definition
  - Phase B – Preliminary Design
  - Phase C – Design and Build
  - Phase D – Assembly, Test and Launch Operations (ATLO)
  - Phase E – Operations

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Scope of Systems Engineering at JPL

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Phases	Advanced Studies	Formulation		Implementation		
	Pre-Phase A	Phase A	Phase B	Phase C	Phase D	Phase E
	Advanced Studies	Mission & System Definition	Preliminary Design	Design & Build	Assembly Test & Launch Ops (ATLO)	Operations

Project Level 2	
"System" Level 3	Flight — *Hardware, Software, Processes* — Ground (MOS, GDS)
Assembly Level 5	

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Systems Engineering Product Domains

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Level 1 SE Domain
- Program SE
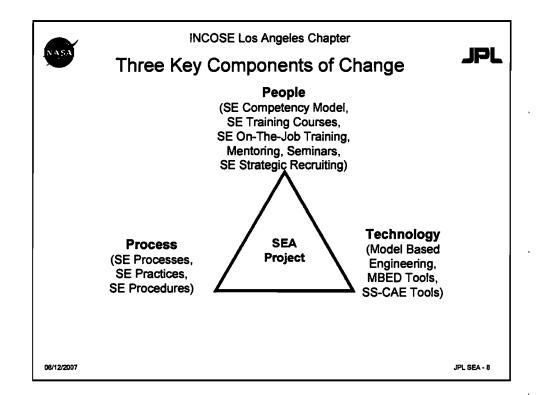
Level 2 SE Domain
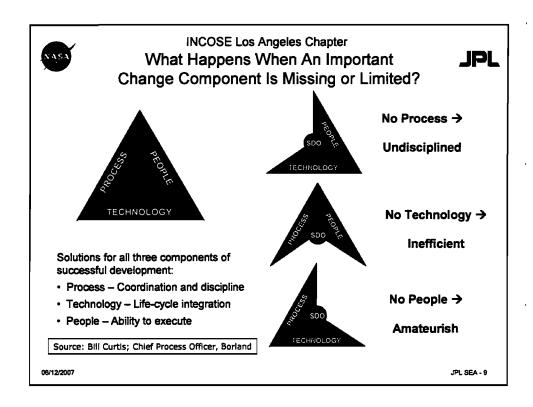- Project SE

Level 3 SE Domain
- Flight System/Spacecraft SE
- Mission Ops Systems (MOS) SE
- Ground Data System (GDS) SE

Level 4 SE Domain
- Spacecraft Avionics SE
- Deep Space Network (DSN) SE
- Guidance, Navigation & Control SE
- Science Instrument/Payload SE
- Mechanical Subsystem SE
- Planning & Execution SE
- Spacecraft Power SE
- Propulsion SE
- Radar SE
- Spacecraft Telecomm SE
- GPS/Tracking Systems SE
- Thermal/Fluid SE
- Project Software SE

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Three Key Components of Change

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People
(SE Competency Model,
SE Training Courses,
SE On-The-Job Training,
Mentoring, Seminars,
SE Strategic Recruiting)

Process
(SE Processes,
SE Practices,
SE Procedures)

**SEA
Project**

Technology
(Model Based
Engineering,
MBED Tools,
SS-CAE Tools)

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What Happens When An Important Change Component Is Missing or Limited?

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No Process →

Undisciplined

No Technology →

Inefficient

Solutions for all three components of successful development:

- Process – Coordination and discipline
- Technology – Life-cycle integration
- People – Ability to execute

No People →

Amateurish

Source: Bill Curtis; Chief Process Officer, Borland
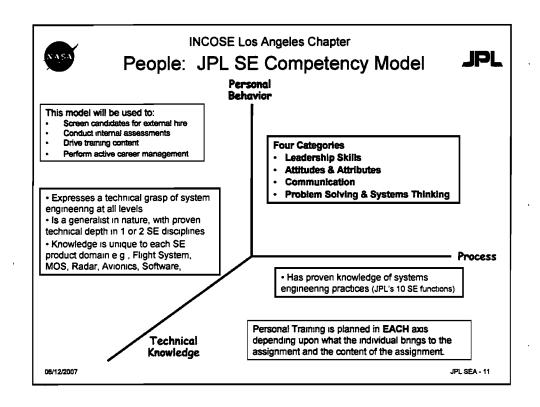
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People Components

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- JPL Systems Engineer Competency Model
- SEA On-the-Job Training (OJT) Program
- SE Training Courses
- SEA Seminar Series

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People: JPL SE Competency Model **JPL**

Personal Behavior

This model will be used to:
- Screen candidates for external hire
- Conduct internal assessments
- Drive training content
- Perform active career management

Four Categories
- **Leadership Skills**
- **Attitudes & Attributes**
- **Communication**
- **Problem Solving & Systems Thinking**

• Expresses a technical grasp of system engineenng at all levels
• Is a generalist in nature, with proven technical depth in 1 or 2 SE disciplines
• Knowledge is unique to each SE product domain e g , Flight System, MOS, Radar, Avionics, Software,

Process

• Has proven knowledge of systems engineenng practices (JPL's 10 SE functions)

Technical Knowledge

Personal Training is planned in **EACH** axis depending upon what the individual brings to the assignment and the content of the assignment

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Background of JPL SE Competency Model **JPL**

- The SEA Project defined the JPL Systems Engineer Competency Model to have three (3) axes: Process, Technical and *Personal Behavior*
- The model will be used to:
  - Screen candidates for external hire
  - Perform internal assessment of SEs
  - Drive training content and active career management
- SEA and HR agreed to have Mary Ellen Derro, an Organizational Development Specialist, define the Personal Behavior axis.
- During SEA conversations with JPL SE stakeholders, JPL Directors identified the highest performing systems engineers.
- The SEA project identified nine high performing SEs to be assessed by her.

- Methodology
  - Conducted one to two hour one-on-one interviews with nine (9) "highly regarded" JPL SE s
    - All SE s were asked a series of eight (8) behavioral questions
    - Two additional questions were asked for recruiting and succession planning purposes
  - Shadowed seven (7) JPL SEs
  - Administered the Myers Briggs Type Indicator (MBTI) to SEs
  - Analyzed data for common themes
    - Grouped information into clusters of competencies with associated behaviors
  - Reviewed and sought concurrence with interviewees on overall competencies.

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People: Personal Behaviors of Highly Valued SEs **JPL**

Leadership Skills
- Has the ability to influence
- Has the ability to work with a team
- Has the ability to trust others
- Communicates vision and technical steps needed to reach implementation
- Mentors and coaches less experienced systems engineers

Attitudes and Attributes
- Has intellectual self-confidence
- Has intellectual curiosity
- Has ability to manage change
- Remains objective and maintains a healthy skepticism

Communication
- Advances ideas and fosters open two-way discussions
- Communicates through storytelling and analogies
- Listens and translates information

Problem Solving and Systems Thinking
- Manages risk
- Thinks critically and penetrates a topic in a methodical manner

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People: JPL SE OJT Program **JPL**
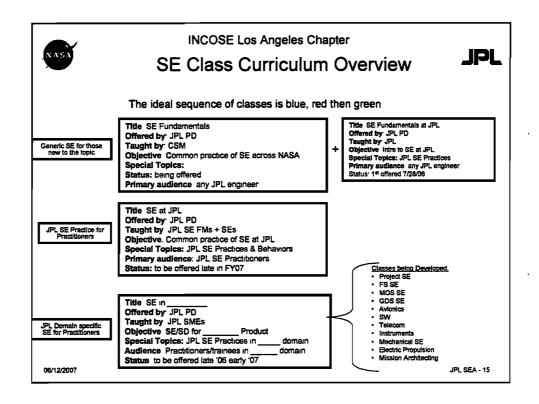
Criteria for JPL SE OJT Candidates

1. **Career Phase**: Is in early or mid career phase
   - Has ~5 to 15 years experience
2. **Potential**: Has the potential of being the best SE in his/her organization
3. **SE Functions**: Appreciates the value of implementing the SE functions
4. **SE Behaviors**: Has many of the preferred SE behaviors
5. **SE Experience**: Has had delivery experience [Cognizant Engineer or ATLO] and SE work experience
6. **SE Domains**: Is representative of a cross section of the 20 flight project product domains at JPL

- Note Items 2-4 above are expected to be enhanced via training and OJT experiences

JPL SE OJT Training Activities
- Protégés average ~32 hours/week on their project and ~8 hours/week on OJT
- Classroom Training
  - General SE classes
  - SE Product Domain classes
  - SE Function classes
  - SE "Lunch and Learn" Domain overview seminars
- Hands-On Flight Project Experience
  - Formulation, Development, and Operations Phases
- 360 Degree Feedback
- SE Mentoring
- Behavior Coaching
- Shadowing SE Masters
- Process Training
- 4D Assessment of SE Practices
- Conferences and Workshops
  - INCOSE, CSER, GSAW, NDIA, IEEE Aerospace, etc

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Slide 1

SE Class Curriculum Overview   **JPL**

The ideal sequence of classes is blue, red then green

Generic SE for those new to the topic

Title SE Fundamentals
Offered by JPL PD
Taught by CSM
Objective Common practice of SE across NASA
Special Topics:
Status: being offered
Primary audience any JPL engineer

+

Title SE Fundamentals at JPL
Offered by JPL PD
Taught by JPL
Objective Intro to SE at JPL
Special Topics: JPL SE Practices
Primary audience any JPL engineer
Status: 1st offered 7/28/06

JPL SE Practice for Practitioners

Title SE at JPL
Offered by JPL PD
Taught by JPL SE FMs + SEs
Objective. Common practice of SE at JPL
Special Topics: JPL SE Practices & Behaviors
Primary audience: JPL SE Practitioners
Status: to be offered late in FY07

JPL Domain specific SE for Practitioners

Title SE in _____
Offered by JPL PD
Taught by JPL SMEs
Objective SE/SD for _____ Product
Special Topics: JPL SE Practices in _____ domain
Audience Practitioners/trainees in _____ domain
Status to be offered late '06 early '07

Classes being Developed.
- Project SE
- FS SE
- MOS SE
- GDS SE
- Avionics
- SW
- Telecom
- Instruments
- Mechanical SE
- Electric Propulsion
- Mission Architecting

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Slide 2

People: SE Courses at JPL   **JPL**

General SE Courses
- Introduction to Systems Engineering at NASA & JPL
- Systems Engineering at JPL
- System Requirements Definition and Management
- How To Document and Track Requirements Using DOORS
- State Analysis: Model and State-Based Systems Engineering
- Verification and Validation
- JPL Project Risk Management Workshop

Systems Design Courses
- NASA Mars Mission and System Design
- Practical Optical Systems Design
- Space Systems I

Domain-Based SE Courses
- Avionics Systems Engineering
- Flight System Systems Engineering
- Ground Data System (GDS) Systems Engineering
- Guidance and Control Systems Engineering
- Mission Architecting
- Mission Operations System (MOS) Systems Engineering
- Project Systems Engineering
- Science Instrument Systems Engineering
- Software Systems Engineering
- Telecommunications Systems Engineering

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People: SEA Seminar Series

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Date	Seminar Topic/Title	Speaker	# Attendees
02/04/2005	From Concept to Creation Using Model-Driven Systems Design Tools	Dr. Joseph Skipper	108
03/04/2005	Design, Operate, Then Build?	Dr Meemong Lee	74
04/08/2005	State Analysis Software Systems Engineering Through Model-Based Architecture	Dr Robert Rasmussen	87
06/01/2005	Overview of the DOD Architectural Framework	Dr. Charles Tang	54
06/03/2005	So You Want To Be A Systems Engineer!	B Gentry Lee	385
07/08/2005	MER Project. Stealing Success From The Jaws of Failure	Rob Manning	176
08/05/2005	You're Gonna Do What! Systems Engineering Challenges at JPL	Riley Duren	119
09/23/2005	MER Project. Stealing Success From The Jaws of Failure (Repnse)	Rob Manning	137
11/04/2005	Market-Based Systems. Bidding Your Way To The Launch Pad	Randii Wessen	42
12/02/2005	Drowning in Details. How Systems Engineering Tools Can Help	Luke Voss	63
01/06/2006	Tying Requirements To Design Artifacts	H Clark Briggs	47
02/08/2006	Developing Requirements A View From The Program Level (Northrop Grumann)	Dr Michael Lembeck, Thomas Zeiller	95
		Total Attendees	1388

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Process: JPL SE Practices

JPL

- **Contents:**
  - A body of requirements on how JPL does systems engineering
  - There are 10 Systems Engineering functions with a total of over 120 requirements and supporting material.
- **Rationale:**
  - There was no JPL SE "standard"
  - A desire to be aligned with NASA requirements and professional "best practices"
- **Goals:**
  - Reduce development and operations risk of our flight projects
  - Improve the efficiency of the implementation of systems engineering
- **How:**
  - Reviewed 14 SE standards and used as "seed material" for SE practices
    - INCOSE, IEEE, NASA SE NPR, GSFC SE Directive, etc.
- **Deployment:**
  - SE Practices will be incorporated into domain-specific local procedures

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Process: SE Practices (Cont.)

JPL

1. **Architecting**
   - The structure of components, their relationships, and the principles and guidelines governing their design and evolution over time

2. **Requirements**
   - The fundamental format of requirements and the process of managing requirements

3. **Analyze and Characterize the Design**
   - The process of thoroughly and accurately analyzing and characterizing the design

4. **Manage Technical Resources and Performance**
   - The process of identifying and managing technical resources and technical performance

5. **Interfaces**
   - The process of developing interfaces and their fundamental contents

6. **Verification and Validation**
   - Verification and validation of the system

7. **Systems Engineering and Reviews**
   - The function of systems engineers in reviews

8. **Systems Engineering and Risk Management**
   - The functions of systems engineers in risk management

9. **Manage and Control Requirements and the Design**
   - The process of maintaining control of requirements and the system design point using established configuration management processes

10. **Manage the Systems Engineering Task**
    - Planning systems engineering aspects of systems development and executing resulting plans

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Essential Elements of Requirements Practices

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JPL Systems Engineering Practices , Rev 0, 23 February 2007

5.1   SEs shall ensure that requirements are specified for the intended use(s) of technical products over their respective lifetimes. **W: prior to PSMR**

    5 13   SEs shall ensure that all requirements are verifiable (See also <u>Verification and Validation Practice #2</u>)

5 6   SEs shall clearly communicate all applicable JPL institutional requirements to all implementing elements. **W: at the start of Phase A**

5 7   SEs shall implement requirements on their systems directly, or develop, allocate, and control requirements for subsystems to implement (See also <u>Architecting Practice #9</u>) **W. at the start of Phase A**

5.10   SEs shall either (a) trace each requirement to its source(s) or (b) identify the requirement as locally-derived and seek its concurrence from the next higher-level element authority **W: prior to PSMR**

5.14   SEs shall ensure that all requirements on an implementing element are reviewed and approved by the stakeholders of the element before the element is implemented. (See also <u>Verification and Validation Practice #5</u>.) **W: prior to PSMR**

5.15   SEs shall ensure that all requirements imposed on an implementing element are reviewed and accepted or rejected by the implementer of the element before the element is implemented. **W: prior to PDR**

5 17   SEs shall use institutionally supported requirements tools selected in <u>Architecting Practice #2</u> to develop and maintain requirements. **W: always**

5 18   SEs shall track, manage and report open requirements, resolving them in a timely manner. **W. prior to PSMR**

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Technology: Model Based Engineering   **JPL**

1. **Conducted Systems Engineering Tool Comparison**
   - **Four Comparison areas:**
     - Architecture & Design Modeling, Executable Modeling & Simulation, Information Management, and Administration & Usage
   - **Functional Modeling Tools**
     - CORE – Vitech Corporation   http://www vtcorp.com
     - Cradle - 3SL   http://www.threesl.com
   - **UML/SysML Tools**
     - Real-time Studio - Artisan Software   http://www.artisansw.com
     - Rhapsody - I-Logix   http://www.ilogix.com
     - TAU – Telelogic   http://www.telelogic.com
   - **Other**
     - TeamCenter Requirements – UGS   http://www.ugs.com
2. **Formed UML/SysML Users Group**
   - **Held quarterly meetings since Jan. 2006 and created website**
3. **Held half-day MBE class and plan lab-wide MBE workshop**
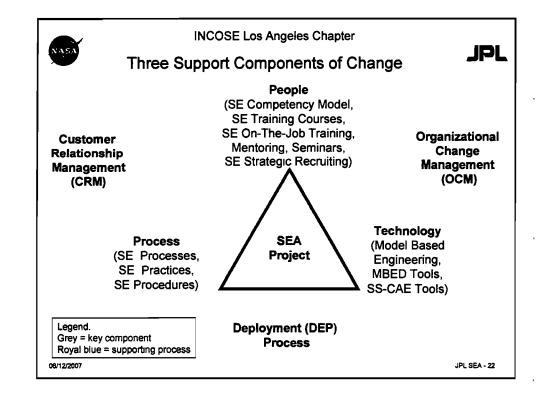
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Three Support Components of Change   **JPL**

People
(SE Competency Model,
SE Training Courses,
SE On-The-Job Training,
Mentoring, Seminars,
SE Strategic Recruiting)

**Customer
Relationship
Management
(CRM)**

**Organizational
Change
Management
(OCM)**

Process
(SE Processes,
SE Practices,
SE Procedures)

**SEA
Project**

Technology
(Model Based
Engineering,
MBED Tools,
SS-CAE Tools)

Legend.
Grey = key component
Royal blue = supporting process

**Deployment (DEP)
Process**

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Customer Relationship Management **JPL**

- The SEA Project takes a proactive approach to Customer Relationship Management (CRM).
  - An approach not usually invoked in an engineering environment.
- CRM is a strategy used to "learn more about customer's needs and behaviors in order to develop stronger relationships with them."
- CRM helps ensure that all products and services truly provide value to the customer, and that the "real" customers are being targeted and reached.
- CRM involves identifying and prioritizing customer target segments, and tailoring the communication messages and approach to their specific needs.

- The SEA Project identified six customer segments and tailored their training and presentations to the unique needs of each segment:
  - Senior Manages, Mid-level Line Management, Project Management, SE Management, Systems Engineering Practitioners (all SE product domains), and Process Improvement customers.
- The SEA Project also prioritized their outreach based on classes of systems, namely:
  - **Primary**: flight and ground systems such as spacecraft, instruments, and associated ground systems.
  - **Secondary**: enterprise, business or administrative systems.
  - **Excluded**: basic research and development, and advanced technology development.

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SEA Customers (Target Audience) **JPL**

#	Customer Segment Name	Target Audience	# In Segment	
0	Senior Managers	Directors For Program Directorates, Engineering and Science Directorate	~ 15	
1	Mid-level Line Management	Section Managers of SE domain sections. Deputy Section Managers of same	~ 82	Excluded Personnel: Basic Research & Development (R&D)
2	Project Management	Project Managers of flight projects	~ 76	
3	Systems Engineering Management	Technical Group Supervisors (TGSs) of SE-intensive groups Mission Assurance Managers (MAMs)	~ 207	
4	Systems Engineering Practitioners	Levels 1 - 5 Systems Engineers	~ 363	
5	Process Improvement	SEA Project Personnel SE Process Engineers ("Blue Team" members)	~ 20	
		Total in JPL SE Community	~ 763	

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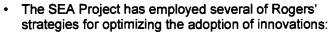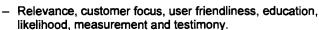
Organizational Change Management

- Organizational Change Management (OCM) is "the methodology that integrates change and the ability to adapt into the organization."
- OCM involves working with a target community to systematically introduce them to desired changes in such a way that those changes are eventually adopted and become commonplace.
  - OCM is based largely on Rogers' seminal work on diffusion of innovation. Everett M Rogers, *Diffusion of Innovations, 5th Edition*, Free Press 2003
  - **This approach is the antithesis of "If we build it, they will come."**
  - **This is a major "paradigm shift."**
- The SEA Project has employed several of Rogers' strategies for optimizing the adoption of innovations:
  - Relevance, customer focus, user friendliness, education, likelihood, measurement and testimony.

If we build it, they will come

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Rogers' Categories of Responses to Innovation

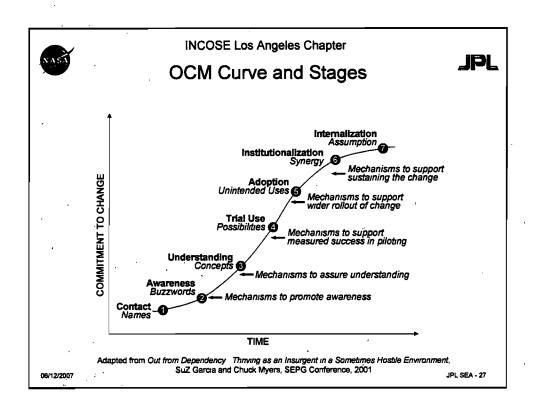| Categories	Characteristics	Responses to Innovation
Innovators or "Techies" – those who create new technologies	Gatekeepers for any new technology, appreciate technology for its own sake; helpful critics	Will settle for buggy or difficult-to-use solution components
Early Adopters or "Visionaries" – those who are the first to try innovations	Dominated by a dream or vision, focus on business goals, usually have close ties with "techie" innovators	Can see the strategic advantage of the improvement or change and are willing to help the org get there.
"The Chasm" in the Adopter Continuum		
Early Majority or "Pragmatists" – those who establish an innovation's success by adopting it for regular use	Do not want to be pioneers (prudent souls), control majority of budget, want percentage improvement (incremental, measurable, predictable progress)	Can see the advantage of the improvement or change and are willing to carefully adopt it
Late Majority or "Conservatives" – those who adopt an innovation after its success has been demonstrated	Avoid discontinuous improvement (revolution), adopt only to stay on par with the rest of the world, somewhat fearful of new technologies	Need a lot of support to adopt the solution component.
Laggards or "Skeptics" – those who never adopt or who do so reluctantly after it becomes necessary	"Nay sayers", adopt only after technology is not recognizable as separate entity, constantly point at discrepancies between what was promised and what is	Are very resistant to changing the status quo, despite the effectiveness of the solution component

06/12/2007   Everett M Rogers, *Diffusion of Innovations, 5th Edition*, Free Press, 2003   JPL SEA - 26

OCM Curve and Stages

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Adapted from *Out from Dependency Thriving as an Insurgent in a Sometimes Hostile Environment,*
SuZ Garcia and Chuck Myers, SEPG Conference, 2001

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SEA Deployment Process

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- **Product/Asset Creation and Review**
  - Generate the asset and conduct internal and external reviews.
- **Infrastructure and Operations**
  - Develop the necessary infrastructure and operations approach for each area
- **Communication and Outreach**
  - Communicate with, and systematically reach out to, the user community so that they know what is available and understand where to obtain it.
- **Education and Training**
  - Provide classroom and computer-based training in the desired processes, products and tools
- **Customer Support**
  - Provide consulting support to projects across a range of relevant topics so that they can use the products in their own environment and for their specific purposes.

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Summary

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1. Changes in how systems are managed, developed and acquired do not come quickly or easily.

2. The improvement process needs to be approached with many of the same deliberate methods and practices that are used in actual system development.

3. It is important to maintain the proper balance between defining processes and generating assets vs. actually deploying them and supporting customers.
   - If this balance is not achieved, all the products generated just become "shelfware."

4. Process improvement needs to be actively supported by three important components – Customer Relationship Management (CRM), Organizational Change Management (OCM) and a known, repeatable Deployment Process – and OCM is where the maximum leverage is gained.

5. It is essential to **proactively reach out to customers** instead of merely waiting for them to come to you.
   - The onus for ensuring change is on YOU.

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Summary (Cont.)

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6. In order to ensure that a cadre of highly trained and skilled systems engineers is available to successfully support systems being developed and operated, sometimes you have to grow your own.
   - This growth process must be approached deliberately, systematically and methodically with the long view in mind.
   - It takes several years to see the fruits of the investment, but it is worth the cost.
   - It needs to be viewed as the cost of doing business and as an investment in the next generation.

7. When training future systems engineers, all three axes of the SE competency model must be addressed — technical knowledge, process knowledge and personal behaviors.
   - The personal behaviors component is where the maximum leverage is gained.

8. Knowing how successful systems engineers behave and sharing that information with the SE community establishes a standard for hiring, evaluation and personnel development.

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Backup Slides

Points To Ponder for <u>Your</u> Organization   **JPL**

- Who are your "customers"? Who are your stakeholders?
- What do you want your customers to be aware of, understand, utilize, and adopt?
- What "assets" do you want to deploy?
- What are the factors that engender acceptance of change? How can you leverage them?
- What are the factors that engender resistance to change? How can you address and mitigate them?
- What infrastructure do you need to build to support deployment?
- What communication vehicles can you use to get our message out?
- What training exists and what needs to be developed?
- Who is available to serve as Subject Matter Experts (SMEs)?
- What would "success" look like? How will you know when you're there?

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Rogers' Diffusion of Innovation Model

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Attributes of Innovation	Strategies for Optimizing Attributes
Relative Advantage – degree to which the innovation is perceived to improve upon existing solutions	**Technology Improvement** – Introduce a new technology that is more powerful than the existing technology
Compatibility – the difficulty associated with mastering the new innovation	**Relevance** – Make sure the problem solved by the innovation is important to adopters **Realism** – Do not try to change too much at once or to please too many different types of users **Customer Focus** – Seek input from current and future adopters and design a solution that they want
Complexity – the difficulty associated with mastering the new innovation	**Developer Friendliness** – Reduce the learning curve for developers of the innovation **User Friendliness** – Reduce the learning curve for adopters by making the innovation easy to learn and use **Reuse** – Reuse as much of the old process and technology as possible **Education** – Provide tutorials and demonstrations to potential users and managers Publish useful information on Web pages and offer pointers to Early Adopters
Trialability – the ability to experiment with the innovation before adopting it in normal operations	**Cost** – Reduce the cost of trial use **Likelihood** – Increase the likelihood that trial use will succeed
Observability – the ease with which improvement is noticed after adoption of the innovation	**Measurement** – Collect data about the old and new technologies for comparison **Testimony** – Provide forums for adopters to describe their experiences **Shadowing** – Provide a side by side comparison by running two projects with the same goals, but with one using the old technology and the other using the new

08/12/2007   Everett M Rogers, *Diffusion of Innovations, 5th Edition*, Free Press, 2003   JPL SEA - 33

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SEA Use of OCM at JPL

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OCM Stages	OCM Stage Name	OCM Definition at JPL	Associated OCM Activities
0	None	Never heard of SEA Project	None
1	Contact	Have heard of SEA Project	SEA publicity and outreach activities – SEA brochure, bookmark, announcements, e-mail, fliers, posters, etc
2	Awareness	Aware of SE standards, practices and procedures, and existence of SEA Seminar Series, SEA website, SEA Road Show, and model-based design concepts	SEA Target Audience list and SE disciplines, SE website, SEA Seminar Series, SEA "Road Show", BEACON SE Online Guide focus groups, surveys, SE procedures and Practices in JPL Rules!, 1-hour MBED Overview/, Stakeholder "Care About" interviews/communications logs
3	Understanding	Understand SE practices and procedures, model-based design concepts, basic SEA products	Systems Engineering at JPL course, SE training courses SE domain training, SEA Seminar Series, SEA "Lunch and Learn" Series, SE function masters, SE Function Master noon-time briefings, SE competency model, 4-hour MBED Tutorial
4	Installation (Trial Use)	Utilize SE practices and procedures, model-based design tools, and some SEA products and services	SEA consulting – planning, SE practices and procedures, , tools, etc , benefits & rationale, case studies, SEA impact metrics, SEA OJT internships, model-based design tools, SS-CAE, contact log
5	Adoption	Some orgs/projects comply with institutional policies and practices (SE practices and procedures), use model-based design tools, apply SE competencies to hiring, annual evaluations (ECAPs) and SE career management	SE target domains, SE Function Master consulting support, more training/coaching, lessons learned, address barriers to change, SE career panels, SE Training & development Profiles, SE Competency model, Fellow-level SE recruiting, ESD model-based systems engineering framework
6	Institutionalization	All orgs and projects performing SE comply with institutional policies and practices (SE practices and procedures), use model-based design tools, apply SE competencies to hiring, annual evaluations (ECAPs) and SE career management	SEA Element activities in concert with ESD line orgs, SEA OCM activities and metrics, SE career panels, SE Training & development profiles, SE competency model and valued behaviors, ESD model-based design Center and consulting support; SEA Level 1 completion metrics, requirements in ECAPs of SE Domain Owners
7	Internalization	Institutional policies and practices (SE practices and procedures) inculcated into ESD line organizations	Appraisals or assessments, continuous process improvement, comprehensive training program, annual institutional performance appraisal of line managers that appropriately rewards and reinforces desired behavior

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DEP: Infrastructure and Operations

JPL

- Involves developing the necessary infrastructure and operations approach for the SEA Project as a whole, and also for each item to be deployed.
- It includes the following items:
  - Electronic library, action item tracking system, configuration management, target audience definition and strategy, CRM database, contact log, metrics collection and reporting, customer e-mail lists, intellectual property approach, and *Deployment and Operations Plan.*
- This infrastructure is the foundation upon which all other aspects of deployment are built.

DEP: Communication and Outreach
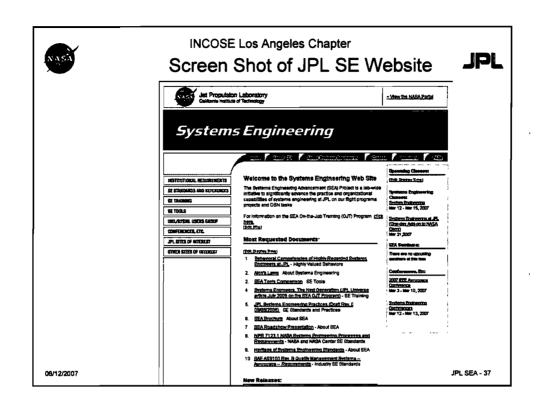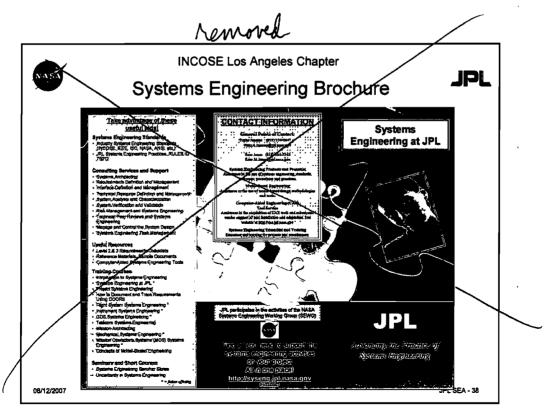
JPL

- Involves communicating with, and systematically reaching out to, the user community so that they know what is available to assist them.
  - Includes a website, brochure, presentations, seminars, OCM approach, surveys, forums, interest groups, etc.
- The SEA Project generated an OCM approach that informs all aspects of their communication and outreach activities.

- **SEA Seminar Series** – Shares processes, practices, and tools for advancing systems engineering
- **SEA Lunch and Learn Series** – Shares information across all the systems engineering disciplines at JPL.
- **UML/SysML User Group** – Supports the specification, analysis, design, verification and validation of systems and software

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Screen Shot of JPL SE Website

JPL

Systems Engineering

Welcome to the Systems Engineering Web Site

The Systems Engineering Advancement (SEA) Project is a lab-wide initiative to significantly advance the practice and organizational capabilities of systems engineering at JPL on our flight programs projects and DSN tasks

For information on the SEA On-the-Job Training (OJT) Program click here.

Most Requested Documents

1. Behavioral Competencies of Highly Regarded Systems Engineers at JPL - Highly Valued Behaviors
2. Akin's Laws - About Systems Engineering
3. SEA Tools Companion - SE Tools
4. Systems Engineers: The Next Generation (JPL Universe article July 2006 on the SEA OJT Program) - SE Training
5. JPL Systems Engineering Practices (Draft Rev. I 08/08/2006) - SE Standards and Practices
6. SEA Brochure - About SEA
7. SEA Roadshow Presentation - About SEA
8. NPR 7123.1 NASA Systems Engineering Processes and Requirements - NASA and NASA Center SE Standards
9. Hierbs of Systems Engineering Standards - About SEA
10. SAE AS9100 Rev. B Quality Management Systems – Aerospace – Requirements - Industry SE Standards

INSTITUTIONAL REQUIREMENTS
SE STANDARDS AND REFERENCES
SE TRAINING
SE TOOLS
DSL/SYSML USERS GROUP
CONFERENCES, ETC.
JPL SITES OF INTEREST
OTHER SITES OF INTEREST

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Removed

Systems Engineering Brochure

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Systems Engineering at JPL

JPL participates in the activities of the NASA Systems Engineering Working Group (SEWG)

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http://syseng.jpl.nasa.gov

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DEP: Education and Training

JPL

- Involves providing educational materials and classroom training in the desired processes, products and tools.
- SEA offers courses on topics such as:
  - Systems engineering, requirements, DOORS requirements tool, domain-specific courses, etc.
- A biannual training survey is conducted in order to gauge training impact and customer satisfaction.
- SEA coordinates an SE On-the-Job Training Program.

DEP: Customer Support (Consulting)

JPL

- Customer Support involves providing consulting support to projects across a broad range of relevant topics so that they can use the products in their own environment and for their specific purposes.
- SEA provides consulting in the areas of:
  - Systems engineering standards, processes, procedures and practices; model-based design methodologies and tools; systems and software computer aided engineering (SS-CAE) tools; use of DOORS for requirements management and V&V, decision analysis, etc.
- Consulting support is provided upon request to projects in the early phases of the system life-cycle.
  - Additional ad hoc consulting is provided as requested to other projects and tasks.

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JPL SE OJT 360 Degree Feedback

- In 360 degree feedback, the protégé receives confidential, anonymous feedback from several people around him/her regarding the degree to which he/she demonstrates the highly valued SE behaviors.
  - Allows the participant to see a more complete picture of his/her strengths & development needs
  - Perception is reality, and this process helps individuals understand how others perceive them
- Confidentiality allows professionals to hear feedback without becoming defensive or feeling publicly exposed.
  - The anonymous nature allows people to communicate feedback that they may have felt uncomfortable sharing otherwise.
- The outcome of the process is a gap analysis between how the person sees himself/herself and how others perceive him/her.
- Feedback is essential for learning.
  - Participants can better manage their own performance and careers.

```
           Manager
              |
              v
Peers  -->  SELF  <--  Customers
              ^
              |
           Team
           Members
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- Each participant receives a printed report of his/her feedback along with coaching.
  - Note that only the coach and the participant actually see the feedback results.
- Afterwards the coach may provide information to help improve the participant's performance, such as relevant articles or books.

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JPL SE OJT Mentoring

- Each SE OJT participant is assigned a mentor who models the highly desired SE personal behaviors.
- The opportunity to observe master SE's conducting real work and observing real-time behaviors is worth a thousand words.
  - Based on the assumption that some things are "better caught than taught."
- Participants are asked to observe a particular behavioral trait and then discuss with their mentor what they observed.
- Participants ground their learning by asking questions about what was observed.
  - What motivated the mentor to behave in a particular manner?
  - What were they hoping to accomplish?
  - Did they achieve the result they were looking for?
  - This also gives the mentor an opportunity to reflect on his/her own behavior.

- The protégé meets with his/her mentor several times per month to discuss the SE behaviors and to be coached in applying them.
- Mentors and protégés also discuss a wide range of topics, e.g.,
  - Role of the SE in risk decisions
  - Problem solving
  - Fault protection
  - Models
  - Architectural decisions
  - SE behaviors
  - Areas of improvement from the 360 degree feedback
  - How to deal with different personalities
  - Overall career path and career development

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JPL SE OJT Coaching

- The OJT participants work with a coach from JPL HR Professional Development to address the results from their 360 degree feedback.
- The coach helps the individual to understand the feedback and keep a balance of positives and negatives.
- The coach also helps to build a realistic view of the development needs.
- Together they establish a practical development plan.
- The coach and OJT participant meet monthly to review progress.

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End of File